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STUDIES ON THE DIGESTIBILITY OF SOME ANIMAL FATS.

By C. F. Langworthy, *Chief*, and A. D. Holmes, *Scientific Assistant*, *Office of Home Economics*.

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INTRODUCTION.

Previous papers [1] reported the results of experiments undertaken to determine the thoroughness of digestion of lard, beef fat, mutton fat, butter, olive oil, cottonseed oil, peanut oil, coconut oil, sesame oil, and cocoa butter, which showed that fairly large quantities of these fats incorporated in a simple mixed diet could be eaten without digestive disturbances and that all were well digested, the coefficient of digestibility being proportional to the melting point of the fat. In continuation of the study of animal and vegetable fats and their dietetic uses, this bulletin reports a study of the digestibility of chicken fat, goose fat, brisket fat, cream, fat in egg yolk, and fat or oil in fish.

Fats are so very similar in their chemical nature that it is natural to assume that they would not differ materially with respect to their food value (of which digestibility is an important factor) under comparable conditions. While race experience would indicate that this is true in the main, there is reason to believe that the question of the digestibility of fats and the closely related matter of the energy which they supply to the body merit further study. That the digestion of different sorts is not alike in all its steps is indicated

[1] U. S. Dept. Agr. Buls. 310 (1915); 505 (1917).

Note.—This bulletin records studies of the digestibility of chicken fat, goose fat, brisket fat, cream, fat in egg yolk, and fat or oil in fish. It is primarily of interest to students and investigators of food problems.

by the work of Tangl and Erdélyi[1] and of Von Fejér,[2] who have observed that fats with a melting point somewhat higher than normal body temperature do not leave the stomach so readily as those of a lower melting point, and, furthermore, that they are not so easily emulsified in the intestine. Apparently no connection has been shown between these observations and thoroughness of digestion. Before one can assume that the fuel value of fat, or more accurately the fuel value of digested fat, actually represents its energy value to the body, one must take into account such work as that of Lusk[3] and his associates, which showed that the digestion and assimilation of foods (including fat) caused an increased output of energy, not ascribable to muscular work, and designated specific-dynamic effect. The test reported did not compare different fats.

That in comparing fats we must consider not alone such questions of thoroughness of digestion and energy expenditure as a result of digestion and their relation to nutrition is apparent from recent work of McCollum and Davis[4] and Osborne and Mendel,[5] who concluded that certain fats carry either as an integral part or as a complement a small amount of substance important in growth. In discussing dietetics, it is commonly assumed that fat and carbohydrates can replace each other as sources of energy in proportion to their theoretical energy values. There are times when it is not wise to do this, at least under pathological conditions, as recent work would indicate, since, according to Ringer,[6] there is a limit beyond which this replacement can not go without serious results, some carbohydrate, it is claimed, being essential for the complete combustion of fat.

EXPERIMENTAL METHODS.

The investigations here reported form a part of a series of studies of the thoroughness of digestion of culinary and table fats of animal and vegetable origin, including those eaten as such, those added to foods in cookery, and those which form an integral part of the foods in which they naturally occur. In all the same general procedure was followed.

The experimental methods were those adopted in earlier work[7] carried on by the department as a part of its investigations of the nutritive value of foods as a result of extended studies of the advantages and disadvantages of differences in technique and in laboratory methods.

The subjects were young men (medical or dental students) in good health, of similar occupation and muscular activity. The diets

[1] Biochem. Ztschr., 34 (1911), No. 1–2, pp. 94–110.
[2] Idem, 53 (1913), No. 1–2, pp. 168–178.
[3] Jour. Biol. Chem., 22 (1915), No. 1, pp. 15–41; Cornell Univ. Med. Bul., 5 (1915), No. 2 (pt. 1, paper 14).
[4] Jour. Biol. Chem., 15 (1913), No. 1, pp. 167–175.
[5] Idem, 16 (1913), No. 3, pp. 423–437; 17 (1914), No. 3, pp. 401–408.
[6] Idem, 17 (1914), No. 2, pp. 107–119.
[7] U. S. Dept. Agr., Office Expt. Stas. Bul. 143 (1904), pp. 57–77.

were simple, the fat-containing food, which was the principal item, being supplemented in each case by carbohydrate foods (such as biscuits or crackers, and mashed potato), fruit (oranges or apples), and tea or coffee with sugar, if a beverage besides water was desired. The subjects were not required to eat like quantities of the food supplying the fat, or of the other foods, but in every case they were expected to eat an amount of fat which would supply about 30 per cent of the total energy value of the ration, this being the quantity which fat contributes to the average American and European diet, as shown by a compilation of data made for this study. With the experimental diets chosen this would mean about 100 grams of fat. Special pains were always taken to use fat which was not rancid, since Adler,[1] on the basis of experimental data, has attributed a hemolytic action to the presence of free fatty acids in foods.

In making up the diets for the experiments a stiff cornstarch pudding or blancmange (heavily flavored with caramel to mask any distinctive fat flavor) was used as a vehicle for the separated fats. The same sort of blancmange was also used in the experiments with cream and egg yolk. For the study of fish oil a typical fat fish was used as the source of the fat.

In these, as in the earlier digestion experiments reported, the three-day or nine-meal test period proved entirely satisfactory. The test periods were followed by rest periods of four days, in which the subjects were permitted to eat whatever they desired. Obviously, the diet during the experimental periods was limited to the prescribed ration. In every case weighed portions of the different foods were prepared in advance for each meal for each subject and the subjects were instructed to reserve any uneaten portions of the diet for weighing, in order that the exact amount eaten might be ascertained. They were also instructed to observe due care in the collection and separation of the feces pertaining to an experimental period.

The records of the experiments include data for the amounts of food eaten and for the feces. Samples of both food and feces were analyzed to determine what percentages of protein and carbohydrate as well as fat were available to the body.

The percentage of fat in the feces was determined by ether extraction of the air-dried sample for 18 to 20 hours by the Soxhlet method, as described by the Association of Official Agricultural Chemists.[2] It is recognized that by this method some fat in the form of soaps may not be extracted. However, comparative tests by the Folin-Wentworth[3] method and the Soxhlet method, made as a part of the digestion work of this office, have given results that are not uniform and are not significant from the standpoint of dietetics.

The ether extract obtained by the method followed is assumed to represent the fat of undigested food, and this quantity less the pro-

[1] Jour. Med. Research, 28 (1913), No. 1, pp. 199–226. [2] U. S. Dept. Agr., Bur. Chem. Bul. 107 (1912).
[3] Jour. Biol. Chem., 7 (1910), No. 6, pp. 424, 425.

portion ascribable to the fat supplied by the basal ration to represent the undigested portion of the fat studied. The significance of such values, in discussing problems of dietetics and the theoretical and other considerations having to do with metabolic products in feces, are fully discussed in earlier publications.[1]

DIGESTION EXPERIMENTS.

CHICKEN FAT.

Although chicken fat as such is not available in quantity in most markets the very large demand for poultry, especially mature poultry, would indicate a very considerable consumption of the fat along with the chicken meat. Little information, however, as to its digestibility and nutritive value has been found in a survey of the literature. In studies of the digestibility of fish and poultry, Milner[2] found that chicken fat eaten as an integral part of poultry in a simple mixed diet was 97 per cent digested.

Several pounds of chicken fat, which had been taken in small quantities from fat birds drawn at the market for those not desiring the excess fat, were procured. It was passed through an ordinary meat grinder and heated in a double boiler to a temperature higher than its melting point, after which the fat was easily separated from surrounding tissues by straining.

For use in the digestion experiments the product was thoroughly mixed and incorporated in a blancmange or cornstarch pudding in the way previously described. Eight experiments of three days' duration were completed in which four normal subjects assisted. The results of these tests are recorded in the following tables:

Data of digestion experiments with chicken fat in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 274, subject H. F. B.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing chicken fat	2,357.0	1,072.0	45.7	359.7	863.6	16.0
Wheat biscuit	545.0	49.0	57.8	8.2	421.3	8.7
Fruit	1,549.0	1,346.1	12.4	3.1	179.7	7.7
Sugar	192.0	.....	.....	.....	192.0	.....
Total food consumed	4,643.0	2,467.1	115.9	371.0	1,656.6	32.4
Feces	148.0	.....	44.4	26.4	65.0	12.2
Amount utilized	.....	.....	71.5	344.6	1,591.6	20.2
Per cent utilized	.....	.....	61.7	92.9	96.1	62.3
Experiment No. 275, subject D. G. G.:						
Blancmange containing chicken fat	1,597.0	726.3	31.0	243.7	585.1	10.9
Wheat biscuit	396.0	35.7	42.0	5.9	306.1	6.3
Fruit	492.0	427.5	3.9	1.0	57.1	2.5
Sugar	158.0	.....	.....	.....	158.0	.....
Total food consumed	2,643.0	1,189.5	76.9	250.6	1,106.3	19.7
Feces	88.0	.....	26.2	15.6	40.1	6.1
Amount utilized	.....	.....	50.7	235.0	1,066.2	13.6
Per cent utilized	.....	.....	65.9	93.8	96.4	69.0

[1] U. S. Dept. Agr., Office Expt. Stas. Buls 126 (1903), pp. 18–20; 193 (1907), pp. 47–59; Connecticut Storrs Sta. Rpt. 1896, pp. 178–180.

[2] Connecticut Storrs Sta. Rpt. 1905, pp. 135, 136.

Data of digestion experiments with chicken fat in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 276, subject R. L. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing chicken fat	2,073.0	942.8	40.2	316.3	759.6	14.1
Wheat biscuit	340.0	30.6	36.0	5.1	262.8	5.5
Fruit	946.0	822.1	7.6	1.9	109.7	4.7
Sugar	43.0	.....	.....	.....	43.0	.....
Total food consumed	3,402.0	1,795.5	83.8	323.3	1,175.1	24.3
Feces	68.0	.....	20.7	17.5	24.0	5.8
Amount utilized	.....	.....	63.1	305.8	1,151.1	18.5
Per cent utilized	.....	.....	75.3	94.6	98.0	76.1
Experiment No. 277, subject O. E. S.:						
Blancmange containing chicken fat	2,380.0	1,082.4	46.2	363.2	872.0	16.2
Wheat biscuit	450.0	40.5	47.7	6.7	347.9	7.2
Fruit	1,505.0	1,307.9	12.0	3.0	174.6	7.5
Sugar	171.0	.....	.....	.....	171.0	.....
Total food consumed	4,506.0	2,430.8	105.9	372.9	1,565.5	30.9
Feces	124.0	.....	36.7	29.9	46.3	11.1
Amount utilized	.....	.....	69 2	343.0	1,519.2	19.8
Per cent utilized	.....	.....	65.3	92.0	97.0	64.1
Experiment No. 290, subject H. F. B.:						
Blancmange containing chicken fat	1,983.0	903.7	37.2	299.4	726.2	16.5
Wheat biscuit	499.0	44.9	52.9	7.5	385.7	8.0
Fruit	1,319.0	1,146.2	10.6	2.6	153.0	6.6
Sugar	127.0	.....	.....	.....	127.0	.....
Total food consumed	3,928.0	2.094.8	100.7	309.5	1,391.9	31.1
Feces	130.0	.....	37.6	23.9	55.4	13.1
Amount utilized	.....	.....	63.1	285.6	1,336.5	18.0
Per cent utilized	.....	.....	62.7	92.3	96.0	57.9
Experiment No. 291, subject D. G. G.:						
Blancmange containing chicken fat	1,250.0	569.6	23.5	188.7	457.8	10.4
Wheat biscuit	480.0	43.2	50.9	7.2	371.0	7.7
Fruit	636.0	552.7	5.1	1.2	73.8	3.2
Sugar	156.0	.....	.....	.....	156.0	.....
Total food consumed	2,522.0	1,165.5	79.5	197.1	1,058.6	21.3
Feces	77.0	.....	23.9	12.0	32.0	9.1
Amount utilized	.....	.....	55.6	185.1	1,026.6	12.2
Per cent utilized	.....	.....	69.9	93.9	97.0	57.3
Experiment No. 292, subject R. L. S.:						
Blancmange containing chicken fat	1,706.0	777.4	32.1	257.6	624.7	14.2
Wheat biscuit	413.0	37.2	43.8	6.2	319.2	6.6
Fruit	646.0	561.4	5.2	1.3	74.9	3.2
Sugar	54.0	.....	.....	.....	54.0	.....
Total food consumed	2,819.0	1,376.0	81.1	265.1	1,072.8	24.0
Feces	66.0	.....	19.5	12.4	27.3	6.8
Amount utilized	.....	.....	61.6	252.7	1,045.5	17.2
Per cent utilized	.....	.....	76.0	95.3	97.5	71.7
Experiment No. 293, subject O. E. S.:						
Blancmange containing chicken fat	1,708.0	778.3	32.1	257.9	625.5	14.2
Wheat biscuit	411.0	37.0	43.6	6.1	317.7	6.6
Fruit	1,273.0	1,106.2	10.2	2.5	147.7	6.4
Sugar	171.0	.....	.....	.....	171.0	.....
Total food consumed	3,563.0	1,921.5	85.9	266.5	1,261.9	27.2
Feces	89.0	.....	26.3	20.7	33.1	8.9
Amount utilized	.....	.....	59.6	245.8	1,228.8	18.3
Per cent utilized	.....	.....	69.4	92.2	97.4	67.3
Average food consumed per subject per day	1,167.8	601.7	30.4	98.2	428.7	8.8

Summary of digestion experiments with chicken fat in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
274	H. F. B.	61.7	92.9	96.1	62.3
275	D. G. G.	65.9	93.8	96.4	69.0
276	R. L. S.	75.3	94.6	98.0	76.1
277	O. E. S.	65.3	92.0	97.0	64.1
290	H. F. B.	62.7	92.3	96.0	57.9
291	D. G. G.	69.9	93.9	97.0	57.3
292	R. L. S.	76.0	95.3	97.5	71.7
293	O. E. S.	69.4	92.2	97.4	67.3
	Average	68.3	93.4	96.9	65.7

The average coefficient of digestibility of the total fat eaten during these tests was 93.4 per cent. As the ether extract of the feces, however, is known to contain metabolic product and undigested fat from the basal ration, which though nearly so was not absolutely fat free, a correction has been applied in the case of this fat and the others studied to determine the average digestibility of total fat consumed. Digestion experiments with the basal ration as the only source of fat have been reported in connection with the earlier animal fat experiments, from which it was concluded that 9.89 per cent of the total weight of water-free feces is made up of metabolic products and undigested fat from the food,[1] which latter must have been an insignificant quantity, since the total amount in the diet was so small. Subtracting the quantity represented by this percentage from the total ether extract of the feces, a value is obtained more nearly representing the weight of unutilized fat. The corrected value for the digestibility of fat then becomes 96.7 per cent.

GOOSE FAT.

In the United States goose fat is used as such only to a very limited extent and chiefly among those of foreign birth or parentage who adhere to special food customs.

Owing to the impossibility of obtaining goose fat in quantity from local dealers, an unusually fat or "stall-fed" goose was purchased. It weighed 27.5 pounds, 13 pounds of fat being obtained when the fat was cut away from the flesh and rendered in the usual way. The goose fat, which at room temperature (about 20° C.) is a soft, pale-yellow, granular solid, tended to separate into two layers on standing—an upper, oily layer, and a lower, more or less solid layer. By using freshly rendered fat, rancidity was avoided, which is likely to occur on keeping, perhaps owing to the 0.7 to 3.5 per cent of soluble fatty acid which the fat contains.

As regards previous work with this fat, Arnschink[2] conducted an experiment of four days' duration with a dog weighing 8 kilograms, in which an average of 50 grams, containing 70 per cent of oleic

[1] U. S. Dept. Agr. Bul. 310 (1915), p. 20. [2] Ztschr. Biol., 8 (1890), pp. 443, 444.

acid and a relatively large amount of free fatty acids was eaten daily and 97.51 per cent digested. So far as can be ascertained, no experiments with human subjects have been recorded. In the work here reported a series of seven digestion experiments has been completed, the essential data of which are given below.

Data of digestion experiments with goose fat in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 209, subject O. E. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing goose fat	1,993.0	940.7	36.7	212.2	789.2	14.2
Wheat biscuit	162.0	14.6	17.2	2.4	125.2	2.6
Fruit	1,735.0	1,507.7	13.9	3.5	201.2	8.7
Sugar	206.0	.....	.....	.....	206.0	.....
Total food consumed	4,096.0	2,463.0	67.8	218.1	1,321.6	25.5
Feces	71.0	.....	18.6	9.7	36.9	5.8
Amount utilized	.....	.....	49.2	208.4	1,284.7	19.7
Per cent utilized	.....	.....	72.6	95.6	97.2	77.3
Experiment No. 262, subject H. F. B.:						
Blancmange containing goose fat	2,424.0	1,100.3	44.6	312.9	947.8	18.4
Wheat biscuit	602.0	54.2	63.8	9.0	465.4	9.6
Fruit	1,178.0	1,023.7	9.4	2.4	136.6	5.9
Sugar	173.0	.....	.....	.....	173.0	.....
Total food consumed	4,377.0	2,178.2	117.8	324.3	1,722.8	33.9
Feces	153.0	.....	39.7	21.5	80.4	11.4
Amount utilized	.....	.....	78.1	302.8	1,642.4	22.5
Per cent utilized	.....	.....	66.3	93.4	95.3	66.4
Experiment No. 264, subject R. L. S.:						
Blancmange containing goose fat	2,059.0	934.6	37.9	265.8	805.1	15.6
Wheat biscuit	321.0	28.9	34.0	4.8	248.1	5.2
Fruit	897.0	779.5	7.2	1.8	104.0	4.5
Sugar	72.0	.....	.....	.....	72.0	.....
Total food consumed	3,349.0	1,743.0	79.1	272.4	1,229.2	25.3
Feces	70.0	.....	22.6	9.6	31.9	5.9
Amount utilized	.....	.....	56.5	262.8	1,197.3	19.4
Per cent utilized	.....	.....	71.4	96.5	97.4	76.7
Experiment No. 265, subject O. E. S.:						
Blancmange containing goose fat	2,451.0	1,112.5	45.1	316.4	958.4	18.6
Wheat biscuit	370.0	33.3	39.2	5.6	286.0	5.9
Fruit	1,219.0	1,059.3	9.8	2.4	141.4	6.1
Sugar	127.0	.....	.....	.....	127.0	.....
Total food consumed	4,167.0	2,205.1	94.1	324.4	1,512.8	30.6
Feces	108.0	.....	30.9	17.5	51.8	7.8
Amount utilized	.....	.....	63.2	306.9	1,461.0	22.8
Per cent utilized	.....	.....	67.2	94.6	96.6	74.5
Experiment No. 282, subject H. F. B.:						
Blancmange containing goose fat	2,357.0	1,118.4	47.1	356.6	822.4	12.5
Wheat biscuit	501.0	45.1	53.1	7.5	387.3	8.0
Fruit	1,406.0	1,221.8	11.3	2.8	163.1	7.0
Sugar	165.0	.....	.....	.....	165.0	.....
Total food consumed	4,429.0	2,385.3	111.5	366.9	1,537.8	27.5
Feces	129.0	.....	34.3	16.1	68.7	9.9
Amount utilized	.....	.....	77.2	350.8	1,469.1	17.6
Per cent utilized	.....	.....	69.2	95.6	95.5	64.0
Experiment No. 284, subject R. L. S.:						
Blancmange containing goose fat	1,469.0	697.0	29.4	222.3	512.5	7.8
Wheat biscuit	357.0	32.1	37.8	5.4	276.0	5.7
Fruit	452.0	392.8	3.6	0.9	52.4	2.3
Sugar	65.0	.....	.....	.....	65.0	.....
Total food consumed	2,343.0	1,121.9	70.8	228.6	905.9	15.8
Feces	83.0	.....	26.8	17.7	29.7	8.8
Amount utilized	.....	.....	44.0	210.9	876.2	7.0
Per cent utilized	.....	.....	62.1	92.3	96.7	44.3

Data of digestion experiments with goose fat in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 285, subject O. E. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing goose fat	1,977.0	938.1	39.5	299.1	689.8	10.5
Wheat biscuit	405.0	36.4	42.9	6.1	313.1	6.5
Fruit	1,083.0	941.1	8.7	2.2	125.6	5.4
Sugar	174.0	.....	.....	.....	174.0	.....
Total food consumed	3,639.0	1,915.6	91.1	307.4	1,302.5	22.4
Feces	99.0	.....	26.5	25.9	38.9	7.7
Amount utilized	.....	.....	64.6	281.5	1,263.6	14.7
Per cent utilized	.....	.....	70.9	91.6	97.0	65.6
Average food consumed per subject per day	1,257.1	667.3	30.1	97.2	453.9	8.6

Summary of digestion experiments with goose fat in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
209	O. E. S.	72.6	95.6	97.2	77.3
262	H. F. B.	66.3	93.4	95.3	66.4
264	R. L. S.	71.4	96.5	97.4	76.7
265	O. E. S.	67.2	94.6	96.6	74.5
282	H. F. B.	69.2	95.6	95.5	64.0
284	R. L. S.	62.1	92.3	96.7	44.3
285	O. E. S.	70.9	91.6	97.0	65.6
	Average	68.5	94.2	96.5	67.0

The average coefficient of digestibility of the fat of the ration, of which over 97 per cent was goose fat, was 94.2 per cent, while 68.5 per cent of the protein and 96.5 per cent of the carbohydrate were retained in the body. Making allowance for the metabolic products and undigested fat (if any) from the basal ration occurring in the ether extract of the feces, the digestibility of goose fat becomes 95.2 per cent. In practically all the tests the subjects reported that the diet had a somewhat laxative effect; in fact, in two or three instances this was so pronounced that it was impossible to complete the test period and to secure the required experimental data. Since an average amount of 95 grams of goose fat was eaten daily, however, without any very pronounced physiological disturbances, it is reasonable to assume that goose fat in smaller amounts would not differ in such respects from other well-known fats, a conclusion borne out by the fact that users of the fat in other countries have found it not only wholesome but desirable.

BRISKET FAT.

In a previous paper [1] a study of the digestibility of beef kidney was reported in comparison with mutton kidney fat and pork kidney fat (lard), which showed differences in digestibility corresponding to the well-known chemical and physical differences between these fats.

[1] Loc. cit.

It seemed of interest also to study the digestibility of the fat from different parts of the same animal, since these are known to vary materially in composition, hardness, culinary qualities, etc. In a series of feeding experiments to determine the best ration to use for producing firm rather than soft pork, Shutt [1] found that the composition and physical properties of fat from animals receiving different rations varied considerably. In some cases the melting point of soft bacon was practically 10° C. lower than that of firm bacon, and the fat of very young pork was almost always softer than that of mature animals. Henriques and Hansen [2] investigated the properties of the outer layer of fat in an animal as compared with that in the interior of the same animal body, reporting that the inner and outer layers of fat are characterized by different iodin numbers and solidification points. In similar studies reported by Richardson,[3] the melting points of samples of leaf lard from oily hogs averaged several degrees higher than the back fat. Richardson and Farey [4] later found that the melting points of samples of back fat, leaf lard, and ham fat varied as much as 12° to 22° C.

While the fat of beef animals may not exhibit as wide a variation in physical characteristics as occurs in other animals, it is well known that brisket fat is quite different from kidney fat. It is softer and has a somewhat granular appearance and has some special culinary uses. Inasmuch as this variation in characteristics exists, it has seemed desirable to test whether there may be a corresponding difference in availability to the body. Accordingly, experiments were undertaken in which the digestibility of brisket fat was studied under conditions identical with those maintained in the study of beef kidney fat.

The material used for this purpose was purchased in the open market, separated from the connective tissues of the brisket by the method of rendering previously described, and incorporated in the blancmange which formed a part of the simple mixed diet used in the digestion experiments. The results of these experiments are tabulated on the following page.

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[1] Canada Expt. Farms Rpts. 1899, pp. 151–155; Canada Expt. Farms Bul., 38 (1901).
[2] Skand. Arch. Physiol., 11 (1901), No. 3–4, pp. 151–165.
[3] Jour. Amer. Chem. Soc., 26 (1904), No. 4, pp. 372–374.
[4] Idem, 30 (1908), No. 7, pp. 1191, 1192.

Data of digestion experiments with brisket fat in a simple mixed diet.

	Weight.	Water.	Protien.	Fat.	Carbohydrates.	Ash.
Experiment No. 338, subject H. F. B.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing brisket fat	1,915.0	817.3	40.7	299.1	750.0	7.9
Wheat biscuit	404.0	37.9	40.4	5.9	313.4	6.4
Fruit	1,705.0	1,481.7	13.6	3.4	197.8	8.5
Sugar	205.0	.....	.....	.....	205.0	.....
Total food consumed	4,229.0	2,336.9	94.7	308.4	1,466.2	22.8
Feces	117.0	.....	42.0	18.2	44.8	12.0
Amount utilized	.....	.....	52.7	290.2	1,421.4	10.8
Per cent utilized	.....	.....	55.6	94.1	96.9	47.4
Experiment No. 339, subject D. G. G.:						
Blancmange containing brisket fat	1,611.0	687.6	34.2	251.6	631.0	6.6
Wheat biscuit	492.0	46.1	49.2	7.2	381.7	7.8
Fruit	1,326.0	1,152.3	10.6	2.7	153.8	6.6
Sugar	113.0	.....	.....	.....	113.0	.....
Total food consumed	3,542.0	1,886.0	94.0	261.5	1,279.5	21.0
Feces	97.0	.....	33.3	14.9	40.5	8.3
Amount utilized	.....	.....	60.7	246.6	1,239.0	12.7
Per cent utilized	.....	.....	64.6	94.3	96.8	60.5
Experiment No. 340, subject R. L. S.:						
Blancmange containing brisket fat	1,845.0	787.4	39.2	288.2	722.6	7.6
Wheat biscuit	336.0	31.5	33.6	4.9	260.7	5.3
Fruit	1,318.0	1,145.3	10.6	2.6	152.9	6.6
Sugar	117.0	.....	.....	.....	117.0	.....
Total food consumed	3,616.0	1,964.2	83.4	295.7	1,253.2	19.5
Feces	92.0	.....	27.1	12.2	43.6	9.1
Amount utilized	.....	.....	56.3	283.5	1,209.6	10.4
Per cent utilized	.....	.....	67.5	95.9	96.5	53.3
Experiment No. 341, subject O. E. S.:						
Blancmange containing brisket fat	1,887.0	805.4	40.1	294.8	739.0	7.7
Wheat biscuit	364.0	34.1	36.4	5.3	282.4	5.8
Fruit	1,627.0	1,413.9	13.0	3.3	188.7	8.1
Sugar	338.0	.....	.....	.....	338.0	.....
Total food consumed	4,216.0	2,253.4	89.5	303.4	1,548.1	21.6
Feces	109.0	.....	36.8	17.3	44.3	10.6
Amount utilized	.....	.....	52.7	286.1	1,503.8	11.0
Per cent utilized	.....	.....	58.9	94.3	97.1	50.9
Experiment No. 347, subject D. G. G.:						
Blancmange containing brisket fat	1,342.0	741.3	26.9	150.3	418.0	5.5
Wheat biscuit	388.0	34.9	41.1	5.8	300.0	6.2
Fruit	1,547.0	1,344.3	12.4	3.1	179.5	7.7
Sugar	92.0	.....	.....	.....	92.0	.....
Total food consumed	3,369.0	2,120.5	80.4	159.2	989.5	19.4
Feces	121.0	.....	41.0	17.4	52.0	10.6
Amount utilized	.....	.....	39.4	141.8	937.5	8.8
Per cent utilized	.....	.....	49.0	89.1	94.7	45.4
Experiment No. 348, subject R. L. S.:						
Blancmange containing brisket fat	1,509.0	833.6	30.2	169.0	470.0	6.2
Wheat biscuit	311.0	28.0	33.0	4.6	240.4	5.0
Fruit	1,440.0	1,251.4	11.5	2.9	167.0	7.2
Sugar	45.0	.....	.....	.....	45.0	.....
Total food consumed	3,305.0	2,113.0	74.7	176.5	922.4	18.4
Feces	83.0	.....	28.8	17.9	28.4	7.9
Amount utilized	.....	.....	45.9	158.6	894.0	10.5
Per cent utilized	.....	.....	61.4	89.9	96.9	57.1
Experiment No. 349, subject O. E. S.:						
Blancmange containing brisket fat	1,936.0	1,069.5	38.7	216.8	603.1	7.9
Wheat biscuit	289.0	26.0	30.6	4.4	223.4	4.6
Fruit	2,314.0	2,010.9	18.5	4.6	268.4	11.6
Sugar	259.0	.....	.....	.....	259.0	.....
Total food consumed	4,798.0	3,106.4	87.8	225.8	1,353.9	24.1
Feces	128.0	.....	42.6	17.6	56.2	11.6
Amount utilized	.....	.....	45.2	208.2	1,297.7	12.5
Per cent utilized	.....	.....	51.5	92.2	95.8	51.9
Average food consumed per subject per day	1,289.3	751.4	28.8	82.4	419.7	7.0

Summary of digestion experiments with brisket fat in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
338	H. F. B	55.6	94.1	96.9	47.4
339	D. G. G	64.6	94.3	96.8	60.5
340	R. L. S	67.5	95.9	96.5	53.3
341	O. E. S	58.9	94.3	97.1	50.9
347	D. G. G	49.0	89.1	94.7	45.4
348	R. L. S	61.4	89.9	96.9	57.1
349	O. E. S	51.5	92.2	95.8	51.9
	Average	58.4	92.8	96.4	52.4

The data of the experiments indicate that the ration supplied 82 grams of fat daily and that this was 92.8 per cent digested. When allowance is made for the small quantity of fat in the basal ration and for the metabolic products in the corresponding feces, the digestibility of brisket fat alone becomes 97.4 per cent. The protein and carbohydrate contained in the diet were 58.4 per cent and 96.4 per cent digested, respectively.

It is interesting to note that the brisket fat is somewhat more completely assimilated than the kidney fat, of which 93 per cent was digested,[1] on an average. Although this difference is not very great, it may contribute added evidence to the theory that the properties of fats vary with the part of the animal body from which the fats are taken.

CREAM.

Owing to the pleasant taste and its very general use in the dietary, the digestibility of milk fat in the form of cream rather than as a separated fat like butter is of particular interest. The question as to whether an emulsion or the separated fat is the more thoroughly digested has been studied by Wells,[2] who found in the case of cod-liver oil that very little difference existed in the digestibility of the two forms. In a series of experiments to determine the influence on metabolism of an excess of fat in the diet, Atwater [3] found that an average of 320 grams of fat daily in a simple mixed diet was 98 per cent digested. Approximately 85 per cent of the total quantity of fat eaten was furnished by cream and milk.

The digestibility of butter, as determined in this office in a series of eight experiments, was found to be 97 per cent,[4] and in a later series of tests, in which the digestibility of the protein of hard palates was studied, butter was found to be 95 per cent digested.[5] Due very possibly to the belief that milk fat in all its forms is equally available to the body, very few similar studies of cream have been reported.

[1] U. S. Dept. Agr. Bul. 310 (1915).
[2] Brit. Med. Jour., 2 (1902), No. 2181, pp. 1222–1224.
[3] Connecticut Storrs Sta. Rpt. 1901, pp. 230–233.
[4] U. S. Dept. Agr. Bul. 310 (1915), p. 21.
[5] U. S. Dept. Agr., Jour. Agr. Research, 6 (1916), No. 17, pp. 641–648.

A series of experiments, accordingly, has been made to determine the digestibility of cream in comparison with that of other fats.

Cream of average quality was purchased of a local dealer and incorporated in a blancmange in the manner previously described, except that, owing to the larger volume of the cream, no skim milk was necessary and a much smaller amount of cornstarch was needed to thicken the mixture. The results of seven digestion experiments, in which five different subjects participated, follow:

Data of digestion experiments with cream in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 180, subject R. L. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing cream	1,461.0	738.8	30.5	149.2	534.3	8.2
Wheat biscuit	328.0	29.5	34.8	4.9	253.5	5.3
Fruit	1,116.0	969.8	8.9	2.2	129.5	5.6
Sugar	82.0	.....	.....	.....	82.0	.....
Total food consumed	2,987.0	1,738.1	74.2	156.3	999.3	19.1
Feces	69.0	.....	21.7	10.6	29.6	7.1
Amount utilized	.....	.....	52.5	145.7	969.7	12.0
Per cent utilized	.....	.....	70.8	93.2	97.0	62.8
Experiment No. 181, subject O. E. S.:						
Blancmange containing cream	1,803.0	911.8	37.7	184.1	659.3	10.1
Wheat biscuit	145.0	13.0	15.4	2.2	112.1	2.3
Fruit	1,547.0	1,344.3	12.4	3.1	179.5	7.7
Sugar	197.0	.....	.....	.....	197.0	.....
Total food consumed	3,692.0	2,269.1	65.5	189.4	1,147.9	20.1
Feces	69.0	.....	18.8	11.4	33.4	5.4
Amount utilized	.....	.....	46.7	178.0	1,114.5	14.7
Per cent utilized	.....	.....	71.3	94.0	97.1	73.1
Experiment No. 182, subject R. F. T.:						
Blancmange containing cream	1,885.0	953.2	39.4	192.5	689.3	10.6
Wheat biscuit	11.0	1.0	1.2	0.1	8.5	0.2
Fruit	1,580.0	1,373.0	12.6	3.2	183.3	7.9
Sugar	88.0	.....	.....	.....	88.0	.....
Total food consumed	3,564.0	2,327.2	53.2	195.8	969.1	18.7
Feces	60.0	.....	12.9	14.2	26.5	6.4
Amount utilized	.....	.....	40.3	181.6	942.6	12.3
Per cent utilized	.....	.....	75.8	92.7	97.3	65.8
Experiment No. 306, subject H. F. B.:						
Blancmange containing cream	2,102.0	1,101.7	47.3	281.2	661.3	10.5
Wheat biscuit	523.0	47.1	55.4	7.8	404.3	8.4
Fruit	717.0	623.1	5.7	1.4	83.2	3.6
Sugar	157.0	.....	.....	.....	157.0	.....
Total food consumed	3,499.0	1,771.9	108.4	290.4	1,305.8	22.5
Feces	140.0	.....	40.2	23.2	64.8	11.8
Amount utilized	.....	.....	68.2	267.2	1,241.0	10.7
Per cent utilized	.....	.....	62.9	92.0	95.0	47.6
Experiment No 307, subject D. G G.:						
Blancmange containing cream	2,179.0	1,142.0	49.0	291.6	685.5	10.9
Wheat biscuit	485.0	43.6	51.4	7.3	374.9	7.8
Fruit	369.0	320.7	3.0	0.7	42.8	1.8
Sugar	137.0	.....	.....	.....	137.0	.....
Total food consumed	3,170.0	1,506.3	103.4	299.6	1,240.2	20.5
Feces	184.0	.....	59.3	32.1	76.2	16.4
Amount utilized	.....	.....	44.1	267.5	1,164.0	4.1
Per cent utilized	.....	.....	43.0	89.3	93.9	12.3

Data of digestion experiments with cream in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 308, subject R. L. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing cream	2,063.0	1,081.2	46.4	276.1	649.0	10.3
Wheat biscuit	330.0	29.7	35.0	4.9	255.1	5.3
Fruit	313.0	272.0	2.5	0.6	36.3	1.6
Sugar	64.0	.....	.....	.....	64.0	.....
Total food consumed	2,770.0	1,382.9	83.9	281.6	1,004.4	17.2
Feces	87.0	.....	28.7	20.4	28.5	9.4
Amount utilized	.....	.....	55.2	261.2	975.9	7.8
Per cent utilized	.....	.....	65.8	92.8	97.2	45.3
Experiment No. 309, subject O. E. S.:						
Blancmange containing cream	2,017.0	1,057.1	45.4	269.9	634.5	10.1
Wheat biscuit	398.0	35.8	42.2	6.0	307.6	6.4
Fruit	767.0	666.5	6.1	1.5	89.0	3.9
Sugar	191.0	.....	.....	.....	191.0	.....
Total food consumed	3,373.0	1,759.4	93.7	277.4	1,222.1	20.4
Feces	109.0	.....	31.3	13.4	55.4	8.9
Amount utilized	.....	.....	62.4	264.0	1,166.7	11.5
Per cent utilized	.....	.....	66.6	95.2	95.5	56.4
Average food consumed per subject per day	1,097.9	607.4	27.7	80.5	375.7	6.6

Summary of digestion experiments with cream in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
180	R. L. S.	70.8	93.2	97.0	62.8
181	O. E. S.	71.3	94.0	97.1	73.1
182	R. F. T.	75.8	92.7	97.3	65.8
306	H. F. B.	62.9	92.0	95.0	47.6
307	D. G. G.	43.0	89.3	93.9	12.3
308	R. L. S.	65.8	92.8	97.2	45.3
309	O. E. S.	66.6	95.2	95.5	56.4
	Average	65.2	92.7	96.1	51.9

It is shown in the summary of the data reported above that the average values for the digestibility of protein, fat, and carbohydrate were 65.2, 92.7, and 96.1 per cent, respectively, when 28, 81, and 376 grams of these constituents were eaten per subject daily. The apparent digestibility of 92.7 per cent for fat becomes 96.9 per cent if allowance is made for the metabolic products and fat of the basal ration occurring in the feces. It was anticipated that much more than 78 grams of milk fat or "butter" would be eaten per subject per day, but the subjects reported that, although the blancmange was of better flavor and smoother texture than that to which they were accustomed, they did not eat as much as usual owing to its being "too rich." The results of the experiments in general, however, would indicate that butter fat supplied in the form of cream is very well assimilated by the body.

EGG-YOLK FAT.

While egg-yolk fat is not separated from eggs for use as food, it has an important place in the dietary, as is evident from the estimate that each egg supplies about 10 grams of the fat. From the results

of a large number of dietary studies, Atwater [1] found that over 4 per cent of the total fat of the diet was furnished by egg yolks. The digestibility of this fat is interesting on these grounds alone, but when it is considered that egg-yolk fat has associated with it other very necessary constituents of the diet, namely, the so-called "growth-maintaining or stimulating factors," which have been the object of considerable recent investigation, it becomes of especial interest. Osborne and Mendel [2] and McCollum and Davis [3] have studied the maintenance and growth-stimulating properties of many fats and have found that egg-yolk fat is one of very few which are efficient in this respect, and it is also a fat relatively rich in lecithin.

Although there is little experimental evidence on the subject, it is generally said that egg yolks are very quickly and completely digested. Observations and experiments on the treatment of the underfed led Stern [4] to conclude that egg yolks are well tolerated and that they may be used to supply a large proportion of the fat of the diet. He found that eggs left the human stomach in from one to one and a half hours, and that the coefficient of digestibility of the fat (as shown by comparison of the food and feces) was from 96.5 to 98.5 per cent.

These results are substantiated by the work of Levites [5] on dogs, in which he found that egg-yolk fat was digested in from one to four hours. This author concluded that egg-yolk fat behaved differently from other fats in the process of digestion, in that the contents removed from the stomach of dogs which had been given egg-yolk fat showed an alkaline reaction, whereas with olive oil an acid reaction was obtained.

According to Lewkowitsch,[6] egg-yolk fat as expressed from the yolks of hard-boiled hen eggs is a yellow oil, while that obtained by ether extraction is a semisolid oil of an orange-yellow color. For the purpose of these experiments, however, it was not considered necessary to express or extract the oil, but instead it was fed as it occurs in the egg. The yolks were carefully separated from the whites, beaten, and incorporated directly in the blancmange, less cornstarch being required, owing to the well-known thickening properties of egg yolks. The blancmange made with egg yolk had a different consistency from that used in previous experiments, being more adhesive and pastelike. It also had a characteristic "eggy" flavor and furnished about four times as much nitrogen as the blancmange made with other fats. Five young men, living under normal conditions, assisted in the experiments reported on the following page.

[1] Connecticut Storrs Sta. Rpt. 1899, p. 82.
[2] Jour. Biol. Chem., 17 (1914), No. 3, p. 405.
[3] Idem, 15 (1913), No. 1, pp. 167–175.
[4] Med. Rec. [N. Y.], 66 (1904), No. 27, pp. 1049–1052.
[5] Biochem. Ztschr., 20 (1909), No. 3–5, pp. 220–223.
[6] Chemical Technology and Analysis of Oils, Fats, and Waxes. London: Macmillan & Co., 1909, 4. ed., vol. 2, p. 395.

Data of digestion experiments with egg yolk in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 214, subject D. G. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Blancmange containing egg-yolk fat	1,826.0	769.7	151.7	267.0	619.3	18.3
Wheat biscuit	303.0	27.3	32.1	4.5	234.2	4.9
Fruit	599.0	520.5	4.8	1.2	69.5	3.0
Sugar	172.0	.....	.....	.....	172.0	.....
Total food consumed	2,900.0	1,317.5	188.6	272.7	1,095.0	26.2
Feces	107.0	.....	31.8	21.8	44.1	9.3
Amount utilized	.....	.....	156.8	250.9	1,050.9	16.9
Per cent utilized	.....	.....	83.1	92.0	96.0	64.5
Experiment No. 215, subject R. L. S.:						
Blancmange containing egg-yolk fat	1,669.0	703.5	138.7	244.0	566.1	16.7
Wheat biscuit	294.0	26.4	31.2	4.4	227.3	4.7
Fruit	648.0	563.1	5.2	1.3	75.2	3.2
Sugar	116.0	.....	.....	.....	116.0	.....
Total food consumed	2,727.0	1,293.0	175.1	249.7	984.6	24.6
Feces	103.0	.....	32.7	21.5	38.4	10.4
Amount utilized	.....	.....	142.4	228.2	946.2	14.2
Per cent utilized	.....	.....	81.3	91.4	96.1	57.7
Experiment No. 216, subject O. E. S.:						
Blancmange containing egg-yolk fat	1,921.0	809.7	159.6	280.9	651.6	19.2
Wheat biscuit	197.0	17.7	20.9	3.0	152.3	3.1
Fruit	1,786.0	1,552.0	14.3	3.6	207.2	8.9
Sugar	224.0	.....	.....	.....	224.0	.....
Total food consumed	4,128.0	2,379.4	194.8	287.5	1,235.1	31.2
Feces	104.0	.....	30.9	23.8	38.5	10.8
Amount utilized	.....	.....	163.9	263.7	1,196.6	20.4
Per cent utilized	.....	.....	84.1	91.7	96.9	65.4
Experiment No. 217, subject R. F. T.:						
Blancmange containing egg-yolk fat	1,220.0	514.2	101.4	178.4	413.8	12.2
Wheat biscuit	51.0	4.6	5.4	.8	39.4	0.8
Fruit	1,731.0	1,504.2	13.8	3.5	200.8	8.7
Sugar	162.0	.....	.....	.....	162.0	.....
Total food consumed	3,164.0	2,023.0	120.6	182.7	816.0	21.7
Feces	62.0	.....	17.4	16.4	20.0	8.2
Amount utilized	.....	.....	103.2	166.3	796.0	13.5
Per cent utilized	.....	.....	85.6	91.0	97.5	62.2
Experiment No. 302, subject H. F. B.:						
Blancmange containing egg-yolk fat	1,316.0	507.2	111.9	251.6	436.9	8.4
Wheat biscuit	456.0	41.0	48.3	6.9	352.5	7.3
Fruit	736.0	639.6	5.9	1.5	85.3	3.7
Sugar	43.0	.....	.....	.....	43.0	.....
Total food consumed	2,551.0	1,187.8	166.1	260.0	917.7	19.4
Feces	127.0	.....	41.3	23.7	50.8	11.2
Amount utilized	.....	.....	124.8	236.3	866.9	8.2
Per cent utilized	.....	.....	75.1	90.9	94.5	42.3
Experiment No. 303, subject O. E. S.:						
Blancmange containing egg-yolk fat	1,380.0	531.9	117.3	263.8	458.2	8.8
Wheat biscuit	330.0	29.7	35.0	4.9	255.1	5.3
Fruit	971.0	843.8	7.8	1.9	112.6	4.9
Sugar	.....	.....	.....	.....	.....	.....
Total food consumed	2,681.0	1,405.4	160.1	270.6	825.9	19.0
Feces	96.0	.....	31.8	21.5	33.9	8.8
Amount utilized	.....	.....	128.3	249.1	792.0	10.2
Per cent utilized	.....	.....	80.1	92.1	95.9	53.7
Average food consumed per subject per day	1,008.4	533.7	55.9	84.6	326.3	7.9

Summary of digestion experiments with egg yolk in a simple mixed diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
214	D. G. G.	83.1	92.0	96.0	64.5
215	R. L. S.	81.3	91.4	96.1	57.7
216	O. E. S.	84.1	91.7	96.9	65.4
217	R. F. T.	85.6	91.0	97.5	62.2
302	H. F. B.	75.1	90.9	94.5	42.3
303	O. E. S.	80.1	92.1	95.9	53.7
	Average	81.6	91.5	96.2	57.6

It may be noted from the recorded data of these experiments that the average amounts of protein, fat, and carbohydrate eaten daily were 56, 85, and 326 grams, of which 81.6, 91.5, and 96.2 per cent were digested, respectively. The reported digestibility of 91.5 per cent for the total fat of the diet is increased to 93.8 per cent for the egg-yolk fat by making allowance for metabolic products and any undigested portion of the small amount of fat the basal ration supplied. Inasmuch as the egg-yolk fat comprised 98 per cent of all the fat supplied by the diet, this derived value should very closely approximate the true digestibility of egg-yolk fat.

In the course of the analytical work it was observed that the ether extracts of both the blancmange and the feces of the experimental periods were of a very dark-orange color, somewhat more intense in the case of the feces. This discoloration can probably be attributed to coloring matter extracted from the egg yolk.

FISH FAT.

Though fish fat or oil (for it is liquid at ordinary room temperature) is not a culinary or table fat in our temperate regions, nevertheless, as it occurs in fish flesh, it forms a not inconsiderable part of the total fat of the diet. This is particularly the case in localities where such fish as mackerel, butterfish, salmon, shad, etc., are eaten in quantity. Except in the case of cod-liver oil, which is a special product used in invalid dietetics chiefly because of the medicinal properties attributed to it, experimental studies of food uses of fish fat or oil are apparently few in number.

Atwater,[1] in a study of haddock compared with beef, reports that the fish fat was 91 per cent digested. Some years later Milner,[2] in experiments with four young men, found that the digestibility of the fat of a lean fish (cod) was practically the same as that of a fat fish (canned salmon), the values being 97.4 per cent and 97 per cent, respectively.

Since fish oil suitable for food purposes was not found on the market and it was not practicable to prepare it in the laboratory, fish containing a fairly high percentage of fat was used instead in the experi-

[1] Ztschr. Biol., 24 (1888), pp. 16–28.

[2] Connecticut Storrs Sta. Rpt. 1905, pp. 116–142.

ments here reported. For convenience it was served in the form of a fish loaf rather than incorporated in a cornstarch blancmange, such as was used with the other fats. With the fish loaf a simple basal ration was served which consisted of potato (boiled and mashed) and biscuits or crackers, fruit (raw apples), and sugar with tea or coffee when such beverages were preferred to water. A small amount of lemon juice was used with the fish as a condiment, but no account was taken of it in computing the nutritive value of the ration.

The fish loaf was prepared as follows: Boston mackerel (a typical fat fish), weighing when cleaned approximately 3 pounds each, were washed and cooked in a covered pan for half an hour in a moderate oven, a little water being added so that the fish would not stick to the pan. The bones, skin, etc., were then removed and the fish flesh minced in an ordinary household meat cutter. The small amount of liquid which remained in the pan was mixed with the minced fish to avoid the loss of any fat which had "cooked out." After seasoning moderately with salt and pepper, the minced fish was formed into a loaf and baked two or three hours in a moderate oven. The crusty surface was removed and the inside portion of the loaf was thoroughly mixed and divided into suitable quantities for the subjects' meals.

Though different in form, the diet was similar in nutritive value to those in the other experiments here reported, fish protein replacing the protein of the skim milk used in making the cornstarch blancmange and mashed potato replacing the cornstarch. That the diets were directly comparable in nutritive value is evident from a comparison of the protein, fat, and energy which the subjects obtained per day from each.

The details of the three experiments which were made follow.

Data of digestion experiments with Boston mackerel in a simple mixed diet.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 444, subject D. G. G.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Boston mackerel (in form of fish loaf)	1,496.0	926.0	323.0	199.9	.....	47.1
Potato	439.0	331.5	11.0	.4	91.7	4.4
Crackers	284.0	19.6	23.0	38.0	201.1	2.3
Fruit	1,320.0	1,116.7	5.3	6.6	187.4	4.0
Sugar	171.0	.....	.....	.....	171.0	.....
Total food consumed	3,710.0	2,393.8	362.3	244.9	651.2	57.8
Feces	67.0	.....	19.3	10.1	31.9	5.7
Amount utilized	.....	.....	343.0	234.8	619.3	52.1
Per cent utilized	.....	.....	94.7	95.9	95.1	90.1
Experiment No. 446, subject R. L. S.:						
Boston mackerel (in form of fish loaf)	1,184.0	732.9	255.6	158.2	.....	37.3
Potato	227.0	171.4	5.7	.2	47.4	2.3
Crackers	243.0	16.8	19.7	32.6	172.0	1.9
Fruit	1,376.0	1,164.1	5.5	6.9	195.4	4.1
Sugar	58.0	.....	.....	.....	58.0	.....
Total food consumed	3,088.0	2,085.2	286.5	197.9	472.8	45.6
Feces	53.0	.....	21.9	7.5	16.2	7.4
Amount utilized	.....	.....	264.6	190.4	456.6	38.2
Per cent utilized	.....	.....	92.4	96.2	96.6	83.8

Data of digestion experiments with Boston mackerel in a simple mixed diet—Continued.

	Weight.	Water.	Protein.	Fat.	Carbohydrates.	Ash.
Experiment No. 447, subject O. E. S.:	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*	*Grams.*
Boston mackerel (in form of fish loaf)	1,348.0	834.4	291.0	180.1	.....	42.5
Potato	476.0	359.4	11.9	.5	99.5	4.7
Crackers	171.0	11.8	13.8	22.9	121.1	1.4
Fruit	1,594.0	1,348.5	6.4	8.0	226.3	4.8
Sugar	165.0	.....	.....	.....	165.0	.....
Total food consumed	3,754.0	2,554.1	323.1	211.5	611.9	53.4
Feces	70.0	.....	28.6	12.2	21.6	7.6
Amount utilized	.....	.....	294.5	199.3	590.3	45.8
Per cent utilized	.....	.....	91.1	94.2	96.5	85.8
Average food consumed per subject per day	1,172.5	781.5	108.0	72.7	192.9	17.4

Summary of digestion experiments—Digestibility of nutrients of entire diet.

Experiment No.	Subject.	Protein.	Fat.	Carbohydrates.	Ash.
		Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
444	D. G. G.	94.7	95.9	95.1	90.1
446	R. L. S.	92.4	96.2	96.6	83.8
447	O. E. S.	91.1	94.2	96.5	85.8
	Average	92.7	95.4	96.1	86.6

As the tables show, the experimental diet supplied, on an average, 108 grams protein, 73 grams fat, and 193 grams carbohydrates per day. The coefficients of digestibility of the entire diet were: Protein, 92.7 per cent; fat, 95.4 per cent; and carbohydrates, 96.1 per cent.

The amount of fat supplied by other foods than fish was only 17.7 per cent of the total fat of the diet. Making due allowance for this small amount of fat other than fish fat made no significant change, the corrected value being 95.2 per cent as compared with 95.4 per cent. This is comparable with the values obtained for other fats of similar physical characteristics and indicates that, like them, fish fat is well assimilated.

SUMMARY.

The fats studied in this investigation were well digested, the coefficients of digestibility, with allowance for metabolic products and any undigested fat supplied by the basal ration, being, for chicken fat, 96.7 per cent; for goose fat, 95.2 per cent; for brisket fat, 97.4 per cent; for butter fat in the form of cream, 96.9 per cent; for the fat in egg yolk, 93.8 per cent; and for the fat in fish flesh, 95.2 per cent.

On an average, 95 grams of chicken fat, 95 grams of goose fat, 80 grams of brisket fat, 78 grams of butter fat in the form of cream, 83 grams of egg-yolk fat, and 60 grams of fish fat were eaten per subject per day. In the case of goose fat, the feces were noticeably soft and occasionally a more decided laxative effect was noted, indicating that the limit of tolerance for this fat was not far above the 95 grams

which was eaten on an average. No physiological disturbance was noted with the other fats tested. Such matters have a practical value in discussing dietetics, aside from the theoretical question whether this laxative property is ascribable to differences in the chemical structure of the fats or to some other factor.

The average coefficient of digestibility of brisket fat is higher than that previously found for beef (kidney) fat (93 per cent),[1] which is in accordance with the observation that the digestibility is inversely proportional to the melting point. The other fats studied were either fluid or had a melting point not far from room temperature, so it was not surprising to find that they did not show marked variations in thoroughness of digestion.

The average digestibility of carbohydrates in the different tests was found to vary only from 96.1 to 96.9 per cent, while the digestibility of this food constituent in the average mixed diet has been found to be 97 per cent.[2] This close agreement would indicate that the consumption of fat did not exercise any unusual effect upon carbohydrate digestion.

As a whole, the results of the digestion experiments indicate that chicken fat, goose fat, brisket fat, cream, egg-yolk fat, and fish fat are all well assimilated and that they are satisfactory sources of fat for the dietary. Since butter fat eaten in the form of cream and egg-yolk fat are very thoroughly digested and easily obtainable and apparently contain or carry with them accessory food substances necessary in the diet for growth and general well-being, a wide use of these two fats in the dietary is especially desirable.

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[1] U. S. Dept. Agr. Bul. 310, p. 21.

[2] Connecticut Storrs Sta. Rpt. 1901, p. 245.

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